

SEM Image Analysis Application

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B.Tech in Computer Science and Engineering

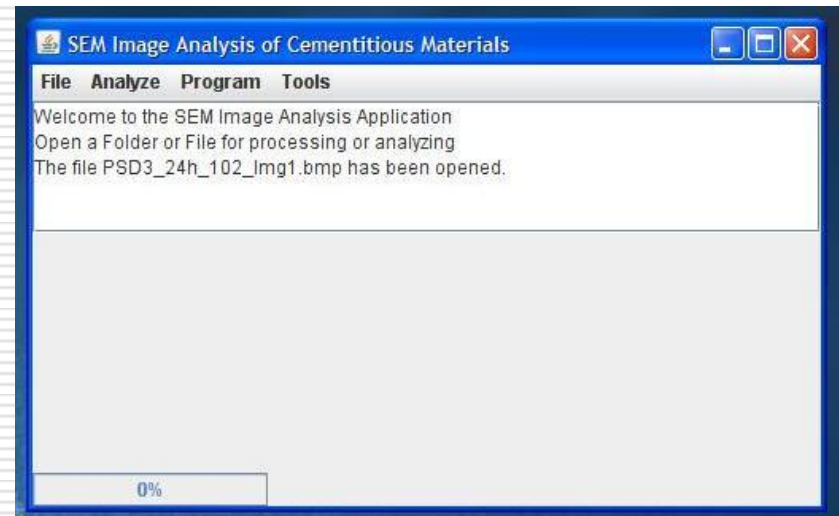
IIT Delhi

Objectives

- ❑ To develop an application for the analysis of images produced by scanning electron microscopy of cementitious materials.
 - ❑ Development of the application in a freely available language to get rid of licensing issues with the existing image processing language and ease of installation and use on any of the lab's computers.
 - ❑ Improvement in existing image processing algorithms and their customization for lab requirements.
 - ❑ Ease of future customizability of software according to changing needs through modularized coding of a set of useful functions. Organization of all important functions used in the application in a separate library for ease of access and use.
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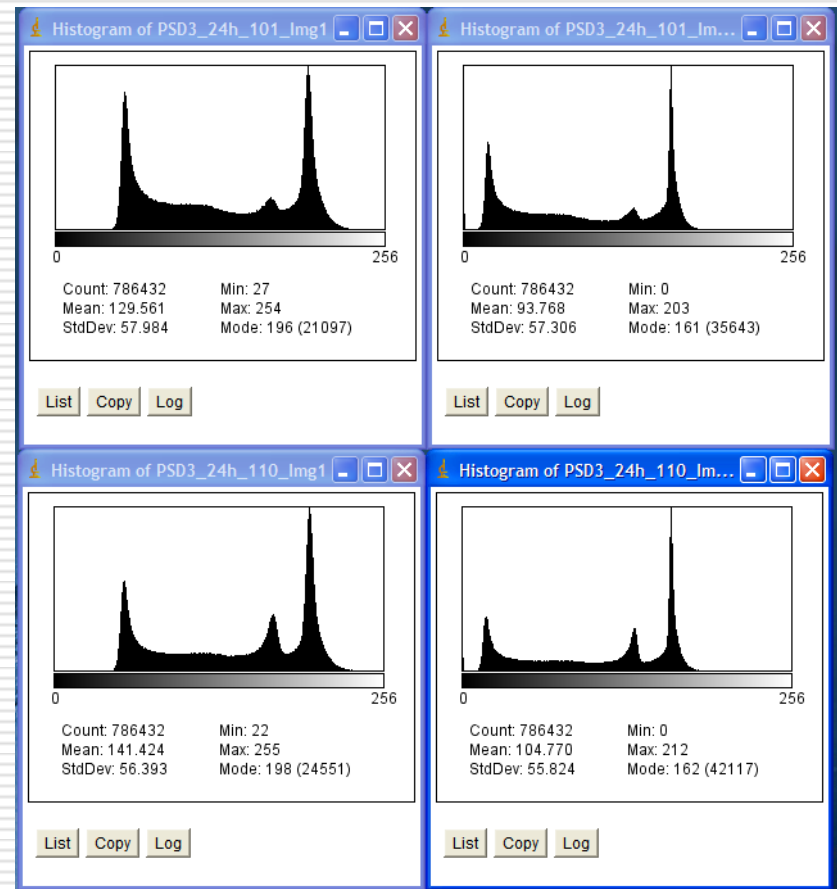
Introduction

- The processing of the images obtained from the SEM basically involves the following steps:
 - Histogram Equalization of all the concerned images.
 - Specification of a sequence of filters for the segmentation and cleaning of each phase required to be analyzed.
 - Application of the sequences to generate segmented images with each phase represented by a different gray level.
 - Generation of a spreadsheet file containing all required information about the phases in the material.



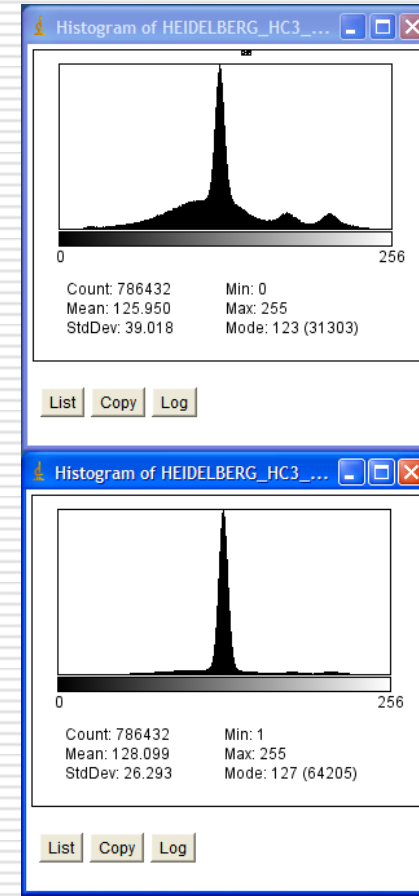
Features: Histogram Equalization

- It is the process in which the histograms of all the images to be processed are normalized to obtain the peaks of the phases aligned with each other.
- Once this is done, the segmentation points for the phases can be found by looking at the histogram of only a single image and used on all images resulting in accurate and efficient segmentation.



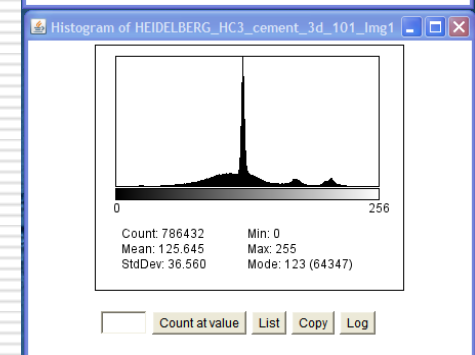
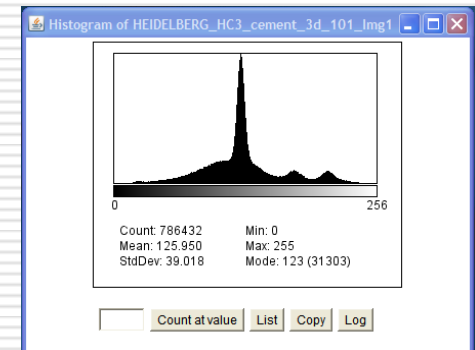
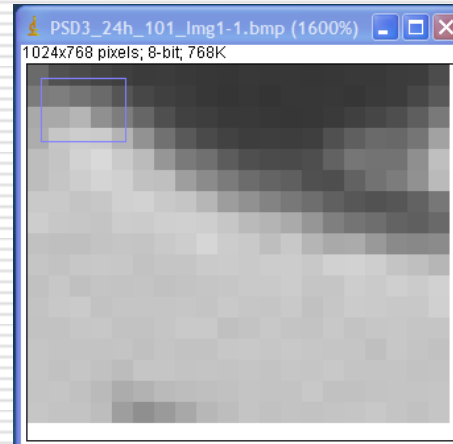
Histogram Equalization Methods

1. Calculation of the cumulative histogram of each image and scaling the images based on two gray levels below and above which 1% of all pixels lie. This works only for model systems.
2. We developed another method which works on most materials like mortar which may have a lot of variation in histograms due to varying amounts of aggregates. In this method, the scaling points are calculated using two of the well-defined peaks in the histogram.



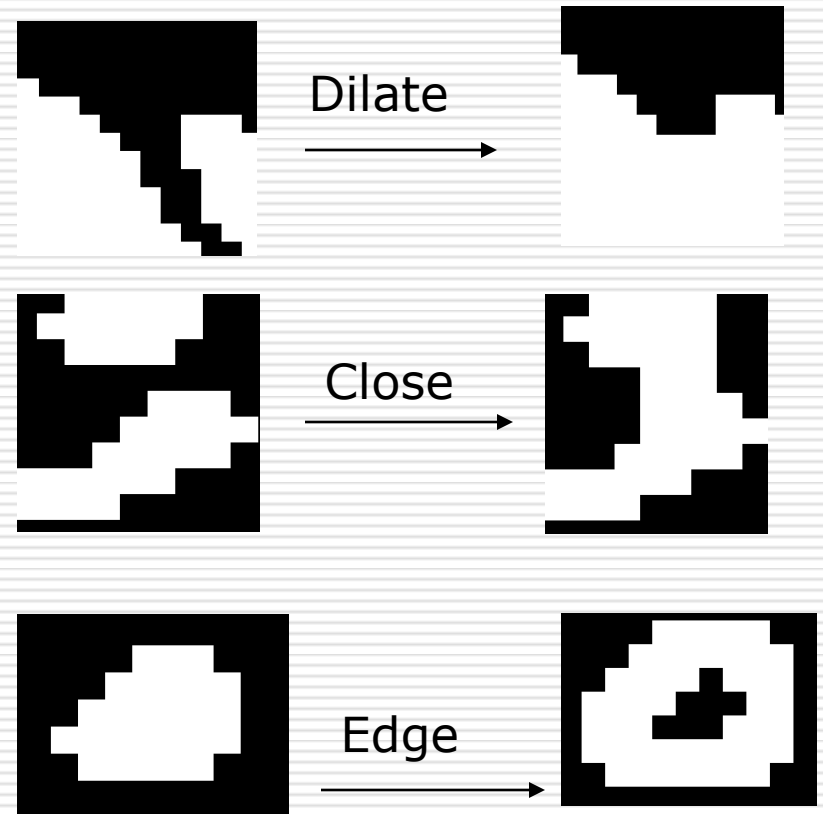
Features: Filters and Tools

- The following basic tools and filters are built in the application using efficient algorithms with customizable strengths:
- Tools:
 - Threshold: Conversion to binary image with only a range of pixels set to white.
 - Fill Holes: Fills internal holes.
- Filters:
 - Median (Enhancement Filter): Reduces noise in the active image by replacing each pixel with the median of the neighbouring pixel values.



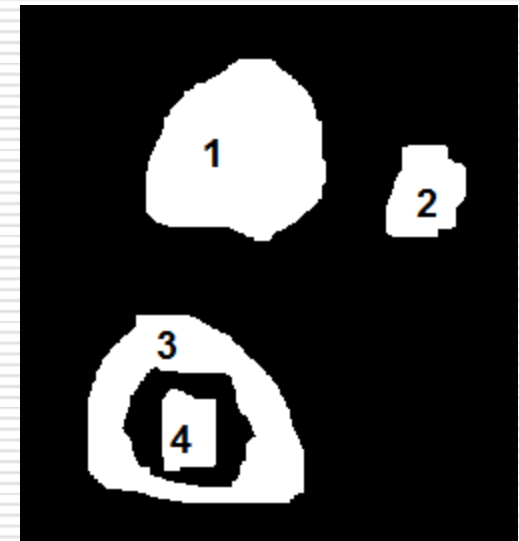
Features: Morphological Filters

- ❑ Dilate: Adds pixels to the edges of white objects.
- ❑ Erode: Removes pixels from edges of white objects.
- ❑ Open: Smooths objects and removes isolated pixels.
- ❑ Close: This smooths objects and fills in small holes.
- ❑ Edge: Finds all edges in the image.



Features: The Blob Detection Tool

- This feature is a very important morphological tool used in shape and size selections.
- It makes a list of all blobs in the image along with their sizes and coordinates.
- Algorithm:
 - We have come up with a sufficiently efficient algorithm for this tool which takes about a second to complete the above operation for a 1024*768 resolution image.
 - This involves scanning the image pixel by pixel and marking each pixel with a number already present among its neighbors or with a new number.
 - Many problems occurred with this approach due to irregularly shaped blobs which were sorted out using a second scan which correctly numbers contiguous sections of blobs numbered incorrectly in the first scan.
- Applications:
 - Errors in image acquisition and irregularities can be easily removed by processing blobs of a certain shape (using the coordinates) or of a certain size.
 - It can also identify blobs within other blobs and makes available all possible data about a segmented image in an easy-to-process form.

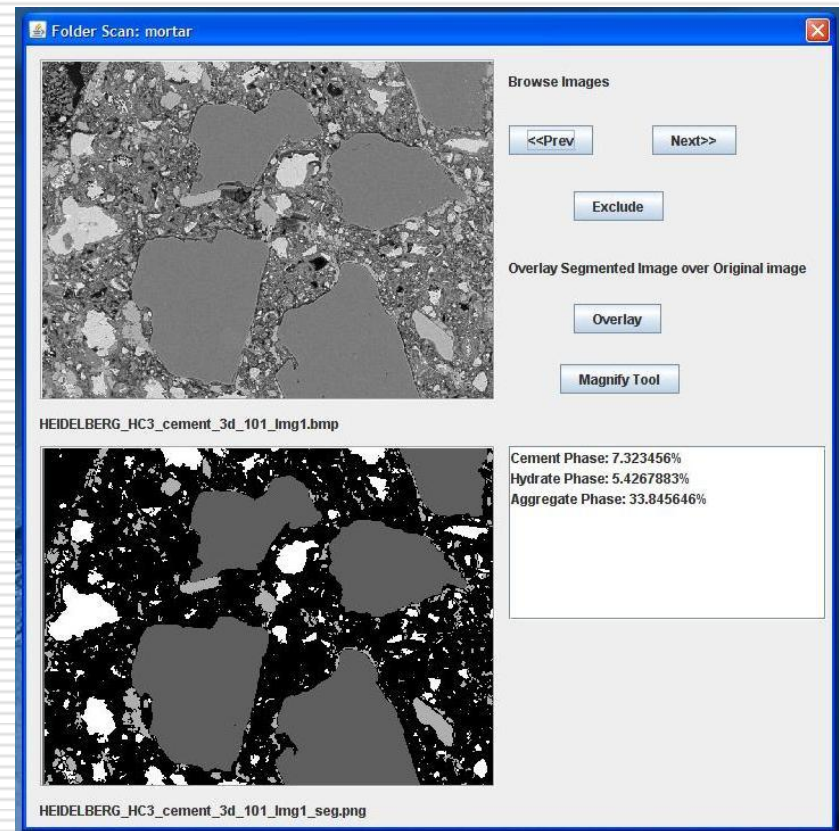


Features: Pre-Programmed Processing Sequences

- Efficient Pre-Programmed Processing Sequences on a collection of images involving normalization, filter application, phase separation and data file generation:
 - Histogram Equalization
 - Model Systems
 - Ordinary Portland Cement
 - Mortar
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Features: Graphical Result Analysis

- Interactive graphical interface for analyzing results of processing:
 - Display of the original and the segmented image alongside with options to browse through the whole folder.
 - Display of data for each phase.
 - Option for excluding certain incorrect samples.
 - Interactive Overlay and Magnify tools to check accurate segmentation.



Custom Programming for Advanced Users

- Ability to define a new processing sequence to be applied on a set of images using all available tools in the application for new materials:
 - Options for histogram equalization and automatic data file generation
 - Filter sequence specification along with their strengths for any number of phases
 - Possibility of using pre-programmed sequences as part of the custom program
- The program then automatically segments each phase separately, applies its filter sequences taking care of selected strengths and combines them into a single image using different colours and calculates all data during processing.

The screenshot shows the 'Customized Image Processing Program' window. It features a 'Name of Program' field, 'Segmentation Directory', and 'No. of Phases' fields. Under 'PROGRAM SEQUENCE', there are checkboxes for 'Histogram Equalization Already Performed' (checked) and 'Data File Generation(Recommended)' (checked). A 'Normalized Histogram' button is present. A table lists filters with their codes and input fields: Threshold (1, 000 to 255), Median (2, Radius(pixels)), Dilate (3, Iterations(01-25)), Erode (4, Iterations(01-25)), Hole Fill (5), Edge (6), Open (7, Iterations(01-25)), Close (8, Iterations(01-25)), Clean Blobs (9, Size(n pixels)). A 'Sequence of Filter Application' area contains two empty boxes. Below the table is a 'PHASES' section with a 'Code' field and 'Add>>' and '<<Remove' buttons. A 'START' button is at the bottom.

FILTER	CODE	Input
Threshold	1	000 to 255
Median	2	Radius(pixels)
Dilate	3	Iterations(01-25)
Erode	4	Iterations(01-25)
Hole Fill	5	
Edge	6	
Open	7	Iterations(01-25)
Close	8	Iterations(01-25)
Clean Blobs	9	Size(n pixels)